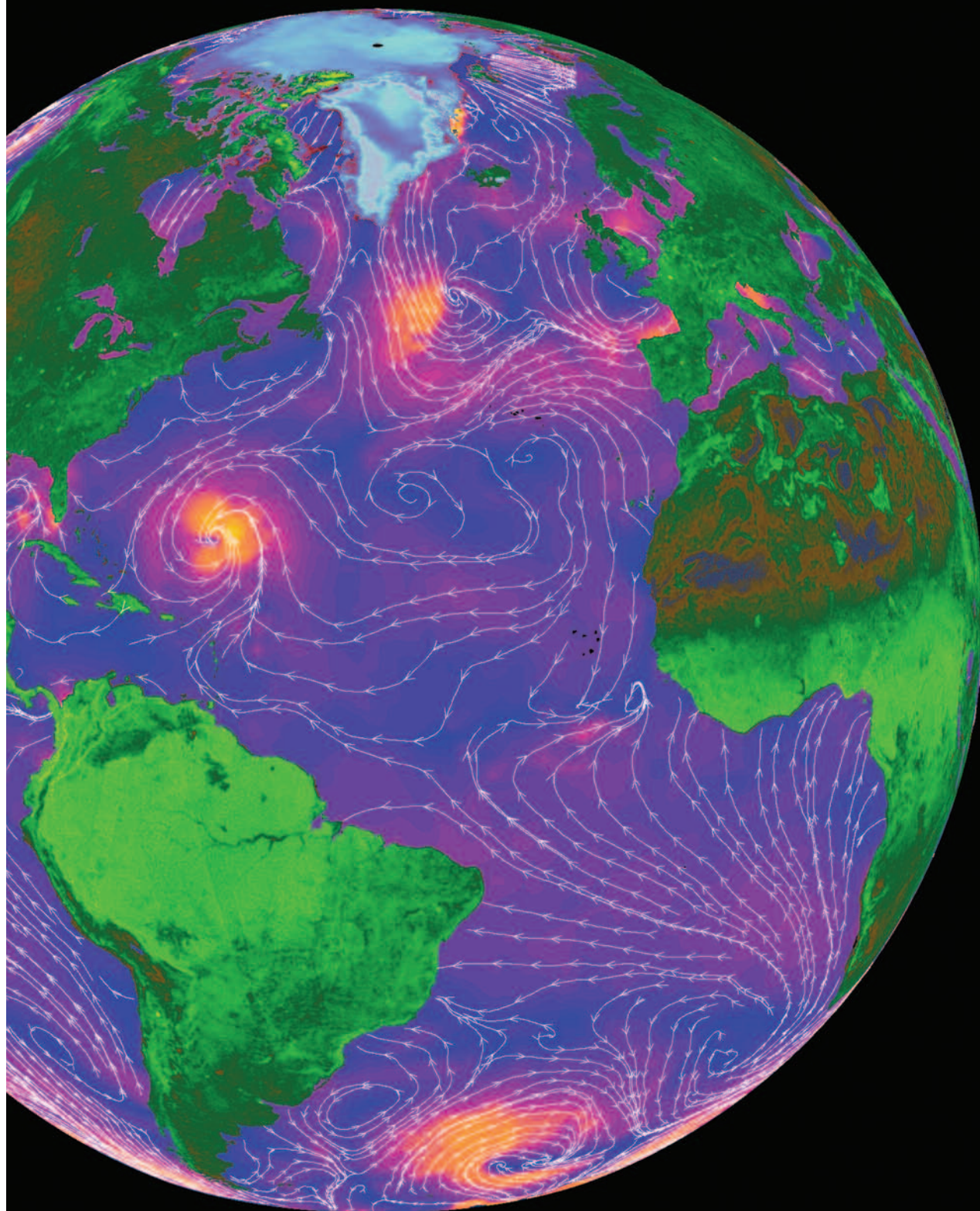


National Aeronautics and Space Administration



2006

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A Guide to NASA Science Mission Directorate Earth System Science Educational Programs and Resources

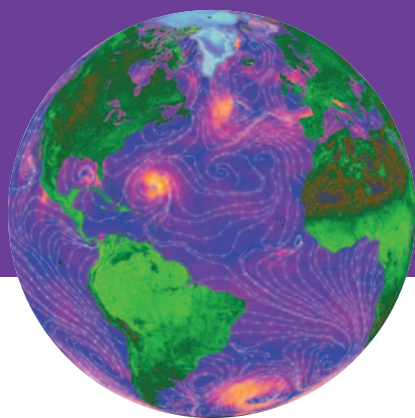
NASA offers a rich suite of programs and resources for educators, parents and students of all levels to actively explore and understand our Earth system. This guide presents a sampling for each level.

For more information on NASA's Science Mission Directorate, visit:

<http://science.hq.nasa.gov>.

For a full listing of NASA Earth science education programs and resources, visit:

<http://science.hq.nasa.gov/education/catalog>.



Cover Image: This QuickSCAT/SeaWinds image shows direction and intensity of surface winds across the Atlantic Ocean. The orange areas show where winds are blowing the hardest, while violet is an intermediate value and blue shows relatively light winds. QuickSCAT data has proven useful in improving forecasts of extreme wind events, such as hurricanes, and in monitoring longer-term climatic effects such as El Niño. For this and other NASA Earth science images, visit: <http://www.visibleearth.nasa.gov>.

K-12

Earth Explorers • http://science.hq.nasa.gov/education/earth_explorers • is a monthly series that introduces you to NASA Earth Explorers, young and old, with a variety of backgrounds and interests. The articles are written in three different versions, one for each of three reading levels: K-4, grades 5-8 and grades 9-12 and up.

EARTH+: Dynamic NASA Earth Science Exploration for Blind Learners • <http://prime.jsc.nasa.gov> • is developing an accessible map interpretation capability for visually-challenged users. The tool will be integrated into existing standards-based, science and math activities for middle school students. Plans are to develop a model lesson for an extreme Earth science scenario, which focuses on the study of dynamics and prediction of hurricanes and their impact on coastal communities. The project team includes experts from NASA Johnson Space Center, the University of Maryland, Baltimore Campus/Goddard Earth Science and Technology Center, and the University of Puerto Rico FILIUS Institute of Disabilities and Rehabilitation Research. All materials are being developed in English and Spanish.

GLOBE • <http://www.globe.gov> • is a worldwide network of K-12 students who conduct grade-level appropriate research on the environment. Under the guidance of trained teachers, students make a core set of environmental observations and report and share their data with other students via the Internet. Scientists use GLOBE data in their research and provide feedback to students. Visualizations based on GLOBE student data can be created on the program's Web site. GLOBE observations and measurements include many variables relating to: atmosphere/climate, hydrology, land cover/phenology, and soils. The idea that Earth is a system of interconnected parts is at the root of the program. GLOBE is an interagency program funded by NASA and the National Science Foundation, supported by the U.S. Department of State, and implemented through a cooperative agreement between NASA, the University Corporation for Atmospheric Research, and Colorado State University in Fort Collins.

The **Measuring Vegetation Health** project • <http://mvh.sr.unh.edu> • is developing hands-on activities for middle and high school students and the public to monitor vegetation health in their own environment, using inexpensive technologies. The activities are sequenced to focus on the local environment, first at very small



From top to bottom:
Photos 1 & 2, Earth Explorers;
photo 3, GLOBE; photo 4,
S'COOL; photo 5, Signals of
Spring

scales, then with increasing spatial coverage. Measuring Vegetation Health will be integrated into both the Global Systems Science curriculum • <http://www.lawrencehallofscience.org/gss> • created by the Lawrence Hall of Science at the University of California, Berkeley, and the University of New Hampshire's Forest Watch program • <http://www.forestwatch.sr.unh.edu> • as well as remote-sensing curriculum developed at Indiana State University. The integrated series will be available as a stand-alone unit that can be incorporated by teachers when needed, as a yearlong curriculum, or as activities for use by museums, science centers, arboretums and botanical gardens.

MY NASA DATA • <http://mynasadata.larc.nasa.gov> • is an effort to develop microsets of Earth science data that are interesting and useful to the K-12 and citizen scientist communities. The project leverages developments in information technology to build user-friendly ways to easily access the data. The datasets can be used with existing curriculum and enable students to practice math skills using real measurements of Earth system variables and processes.

MY NASA DATA microsets are created using data from NASA Earth science satellite missions and provide information on the atmosphere, ocean and land surface. New data types continue to be added to the collection. Data is available online along with lesson plans, computer tools and an Earth science glossary.

The New York City Research Initiative: NYCRI • <http://education.gsfc.nasa.gov/nycr> • is a NASA-sponsored program in which 30 teams of high school and college students and teachers are working with graduate students and scientists at 12 universities in New York, New Jersey and Connecticut, and at NASA Goddard Institute for Space Studies in Manhattan. In addition to performing research associated with NASA projects, participants attend conferences and weekly seminars, present oral reports, and visit nearby laboratories, museums and science centers. NYCRI also has an academic year component in which high school and college teachers incorporate NASA research into the classroom.

OceanWorld • <http://oceanworld.tamu.edu> • is filled with oceans-related information and resources for middle-high school and college audiences. This Web site also includes lessons and activities, college-level courses and textbooks, sources of real-time data that can be used in the classroom, and links to numerous oceans references.

Project 3-D VIEW (Virtual Interactive Environmental Worlds) • <http://www.3dview.org> • engages students in Earth system science with immersive 3D views. The program combines NASA mission data with 3D technologies in grades 5 and

6 as students become 'explorers' while working in five units: lithosphere (land), hydrosphere (rivers/oceans), biosphere (life), atmosphere (air) and Earth systems. A project goal is for students to understand Earth system science topics and science-based decision making, preparing them for high school and beyond. Using simple Web interfaces and a custom viewer, students explore, create, manipulate and navigate 3D stereo views. Project 3D-VIEW is aimed at increasing student achievement in middle school science by using 3D technology to help students to truly understand abstract concepts.

Students' Cloud Observations On-Line: S'COOL

• <http://scool.larc.nasa.gov> • is a component of NASA's CERES (Clouds and the Earth's Radiant Energy System). The CERES instrument measures the amount of energy reflected and emitted by the Earth system. It focuses on understanding how clouds affect these energy transfers.

Participating students make basic weather observations and record the type and features of clouds in the sky at the time the satellite is scheduled to pass over their location. The data is then submitted to NASA (by Web, email, fax or mail) for entry into an online database. Students can access their results as well as those from other participating schools using the S'COOL Web site (which is available in six other languages). Satellite observations for matching times are also posted so that students can compare their observations to those of the satellite, and scientists can evaluate CERES' performance. Participants receive instructional materials, a schedule of satellite overpass times and information necessary for reporting results.

In the **Signals of Spring** program • <http://www.signalsofspring.net> • middle and high school students investigate migration patterns of land and marine animals. Animal location data relayed from small satellite transmitters can be overlaid onto maps of topography, vegetation, sea surface temperature and other variables, prompting students to pose and research questions about the many factors affecting the migration and health of different species. Students log their observations and analyses in online journals, which are then read and commented on by Earth scientists and wildlife biologists. The program provides teacher training, which can be conducted onsite or by live, interactive Webcasts.

The Space Place • <http://spaceplace.nasa.gov> • Web site for elementary-age kids features games, animations, projects, a cartoon talk show, and amazing facts related to Earth, space and technology. The Teachers Corner contains curriculum supplements originally published in the *Technology Teacher* magazine. Available in Spanish at • <http://spaceplace.nasa.gov/espanol>.



From top to bottom:
Photo 1, DEVELOP; photo 2, ESSE 21; photo 3, MS PHD's Ocean Science Program; photo 4, Remote Sensing Explorers at ECSU; photo 5, Eyes on Earth

Higher Education

DEVELOP • <http://develop.larc.nasa.gov> • is a NASA Applied Sciences human capital development program. Student teams across the U.S. conduct pilot projects that demonstrate to community leaders how NASA Earth science data and technology can be applied to local policy issues. Each DEVELOP project is student-led, with NASA scientists serving as advisors. The student projects cover NASA applications areas that have been identified as national priorities: agricultural efficiency, air quality, aviation, carbon management, coastal management, disaster management, ecological forecasting, energy management, homeland security, invasive species, public health and water management.

The Earth System Science Education for the 21st Century program – ESSE 21 • <http://www.usra.edu/esse/essonline> • offers small grants to colleges and universities, especially minority institutions, to spark collaboration among educators and scientists in developing undergraduate and graduate courses, curriculum materials and degree programs in Earth system science. ESSE 21 is sponsored by NASA and managed by the Universities Space Research Association.

NASA's Earth System Science Fellowship Program sponsors fellowships for students pursuing Master of Science or Doctoral degrees in Earth System Science and related disciplines. The program's purpose is to ensure continued training of interdisciplinary scientists to support the study of the Earth as a system. NASA places particular emphasis on the applicant's ability and interest in pursuing academic training and research using observations and measurements from NASA's Earth-orbiting satellites, and in developing inter- or cross-disciplinary research about the Earth system that is not currently emphasized in the research and development portfolio of NASA's Science Mission Directorate. The annual program announcement is released in the fall and posted at • <http://inspires.nasaprs.com>.

GeoBrain • <http://geobrain.laits.gmu.edu> • will mobilize NASA Earth Observing System (EOS) data and information through Web service and knowledge management technologies for higher-education teaching and research. The technologies, based on geo-object and geo-tree concepts, will be implemented in a Web information system that makes huge sets of NASA EOS data and information easily accessible to faculty and students. The system will allow users to dynamically and collaboratively develop interoperable, Web-executable geospatial service modules and models, and run them online against any part of the archived data, to get back customized information products rather than raw data. George Mason University's Laboratory for

Advanced Information Technology and Standards is conducting this innovative project.

MS PHD'S®: Minorities Striving and Pursuing Higher Degrees of Success in Earth System Science • <http://www.msphds.usf.edu> • is a professional development program developed by and for underrepresented minorities, with the overall purpose of increasing their participation in Earth system science. The program provides undergraduate and graduate students with increased exposure to the Earth system science community, improved professional skills and networking opportunities.

Remote Sensing Explorers • <http://cerser.ecsu.edu/rse> • is a partnership between Elizabeth City State University in North Carolina and the University of New Hampshire to deliver two-week long, professional development workshops for university faculty from minority-serving institutions. The summer workshops are designed to assist faculty with developing, delivering and evaluating two inquiry-based courses (Earth System Science and Remote Sensing Methods) at their home institutions.

Satellite Observations in Science Education: SOSE • <http://www.ssec.wisc.edu/sose> • provides an Internet-based education environment for postsecondary students with interactive learning experiences in remote-sensing principles and exploratory data analysis. A major goal for this project is to offer a toolkit of *Reusable Content Objects* and *Reusable Evaluation Objects* that can be downloaded and easily edited by educators to build learning activities for any subject.

Summer Fellowships for Undergraduate and Graduate Students

NASA offers summer research opportunities for college students, which typically last ten weeks, at NASA field centers where students are paired with a NASA scientist mentor. Programs for postsecondary students include:

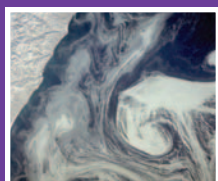
- Summer Institute on Atmospheric, Biospheric, Hydrospheric, and Solar and Space Plasma Sciences—
<http://neptune.gsfc.nasa.gov/summerinstitute>
- NASA Academies for undergraduates and graduate students—
<http://www.nasa-academy.nasa.gov>
- Graduate Student Summer Program in Earth System Science—http://gest.umbc.edu/student_opp/students.html

For a full listing of available NASA Earth science education programs & resources, visit:
<http://science.hq.nasa.gov/education/catalog>

For the Latest NASA Earth Science and Education

Subscribe to the **NASA Earth Science Education Update** a monthly email newsletter featuring the latest programs and resources for all levels of formal and informal education. To subscribe, send an email to: esnewsletter@hq.nasa.gov. Back issues are available at: <http://science.hq.nasa.gov/education/edreports>.

NASA's Earth Observatory <http://earthobservatory.nasa.gov> is an interactive Web-based magazine where the public can obtain new satellite imagery and scientific information about our home planet. Visit the Earth Observatory to read feature articles on wide-ranging Earth system science topics, download datasets and images for analysis, read breaking news, learn about current and planned Earth missions, search an online library for reference materials, track natural hazards around the world in near-real time, and access interactive experiments and classroom activities.



Sources of Earth Imagery

■ INTRODUCTORY/INTERMEDIATE

The Gateway to Astronaut Photography of Earth <http://eol.jsc.nasa.gov> hosts the most complete online collection of astronaut photographs of the Earth, including photos from the Space Shuttle and the International Space Station. Users can search by geographic coordinates or region, mission, features, cloud cover, and many other options. Special collections include: Cities, Hurricanes and Weather, Earth's Water Habitat, and Geographical Regions.

NASA's Visible Earth <http://www.visibleearth.nasa.gov> is a comprehensive image gallery (currently almost 34,000 images) providing access to NASA Earth science images, animations and data visualizations. Most resources are available digitally at multiple resolutions, with captions and metadata. Search by keyword or browse images by mission/sensor, geographic region, and topic.

■ ADVANCED

NASA's Earth Observing System Data and Information System (EOSDIS) <http://nasadaacs.eos.nasa.gov> manages and distributes a wide variety of interdisciplinary Earth system science data and services through nine data centers. To learn more about how scientists have used data from NASA's Earth Science Data Centers in their research, see: <http://nasadaacs.eos.nasa.gov/articles/index.html>.

Daily MODIS Rapid Response Imagery <http://rapidfire.sci.gsfc.nasa.gov> are available in near real time for a number of applications including fire monitoring, burn area mapping, crop monitoring, flood mapping and air quality monitoring.

Informal Education

Earth & Sky • <http://www.earthsky.org/shows/observingearth.php> • is heard by millions of listeners each day on more than 1,000 commercial and public radio affiliates in the United States, on the Sirius and XM Satellite Radio networks, and internationally by Podcast and on dozens of independent stations and networks including American Forces Radio, World Radio Network and Voice of America. NASA sponsors a series of Earth science shows on Earth & Sky. Each 90-second show is based on interviews with NASA scientists and includes links to related Web sites.

Earth Update • <http://earth.rice.edu/connected/earthupdate.html> • is a graphical interface on CD-ROM, which allows access to Earth science information, animations, games and activities for K–12. It is organized by spheres: atmosphere, biosphere, geosphere, hydrosphere and cryosphere; the modules can be run alone, or as a linked system. Each sphere contains a library of hot topics, general topics and images that can be updated over the Internet, as well as who, what, how and why sections. The Houston Museum of Natural Science developed Earth Update as an interactive museum display, but it is fun and educational for learners of all ages.

Eyes on Earth • <http://www.oms.edu/visit/earth/eyesonearth> • is a 2,500 sq. ft. interactive, traveling science exhibition developed by the Oregon Museum of Science and Industry (OMSI) that focuses on NASA's Earth Observing System (EOS) and explores three major areas: Satellites, Orbits and Satellite Technology. Designed primarily for families and school groups (upper elementary+), Eyes on Earth brings these concepts down to Earth through a combination of fun, accessible interactives. The exhibit is available for leasing from MSI through 2010.

In 2005, MSI received funding from NASA for a new traveling exhibition, **A View From Space**. This 700 sq. ft., interactive exhibit focuses on the imagery and data collected by NASA's EOS, its interpretation by NASA scientists, and how the information affects the general public. The exhibit is available for leasing through 2013 and is targeted at smaller and rural museum venues.






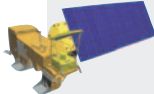











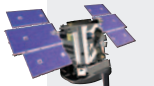

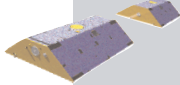








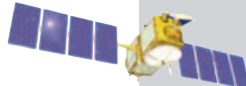







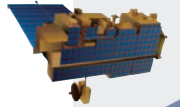








Immersive Earth • <http://earth.rice.edu/connected/globetheater.html> • produces movies that teach Earth science concepts using immersion in dome-shaped theatres. Through NASA funding, Rice University and the Houston Museum of Natural Science are partners in the five-year project that involves six museums, two universities and three private companies. Multiple projectors display the computer-generated images around all 360 degrees of a planetarium or large dome-shaped theatre. A single-projector system developed by the project allows for showings in portable inflatable domes, small enough to be brought out to schools and other venues. Over 25,000 have seen the shows in portables so far, including rural and tribal sites.

Science Bulletins • <http://sciencebulletins.amnh.org> • from the American Museum of Natural History brings free, current science to the general public, informal learning centers and classrooms. The bulletins include three types of stories: features, data visualizations and weekly news snapshots. A video and editorial crew follows scientists into the field to capture original video material and interview scientists about their work-in-progress for the feature stories, which are presented as high-definition videos for informal learning centers and as rich-media collections on the Web. Data visualizations in the Earth and Bio sections are based on satellite data sets from NASA and NOAA and presented in high-resolution for informal learning centers and in interactive formats on the Web. A free educator's guide and learning activities are also provided on the Web site.

Education and Public Outreach

NASA's Earth science missions provide education and public outreach programs and resources for educators, students of all ages and the public. These include teacher workshops, student projects, and public programs and events as well as instructional

materials and resources, such as Web sites, CDs, posters, videos and brochures. Visit the individual mission Web sites identified below for specific information on their programs and resources, including mission results, satellite imagery and other data.

	Mission/Description/URL	Launch	Earth Measurements				
			 Air	 Land	 Water	 Ice	 Life
	Aqua Earth's water cycle, energy fluxes, aerosols, land vegetation cover, ocean phytoplankton, sea & land ice, & air/land/water temperatures • http://aqua.nasa.gov	2002					
	Aquarius Understanding the interaction between ocean circulation, the water cycle & climate by measuring ocean salinity • http://aquarius.gsfc.nasa.gov	2009					
	Aura Composition, chemistry & dynamic of Earth's atmosphere as well as study the ozone, air quality & climate • http://aura.gsfc.nasa.gov	2004					
	CALIPSO Cloud-Aerosol Lidar & Infrared Pathfinder Satellite Observations • Effects of aerosols & clouds on climate • http://www-calipso.larc.nasa.gov	2006					
	CloudSat Structure, composition & effects of clouds on a global basis • http://cloudsat.atmos.colostate.edu	2006					
	GRACE Gravity Recovery & Climate Experiment • Map Earth's gravity fields • http://www.csr.utexas.edu/grace	2002					
	ICESat Ice, Cloud, and land Elevation Satellite • Ice sheet mass balance, cloud & aerosol heights (esp. over polar areas), land topography, & vegetation (polar & global) • http://icesat.gsfc.nasa.gov	2003					
	Jason-1 Monitor ocean surface topography & global ocean circulation to improve global climate predictions, & monitor events such as El Niño conditions & ocean eddies • http://sealevel.jpl.nasa.gov	2001					
	Landsat Program Nearly 35 continuous years of data & images map the globe's changing continental & coastal areas on a landscape-scale • http://landsat.gsfc.nasa.gov	2000					
	Orbiting Carbon Observatory (OCO) First space-based measurements of atmospheric CO ₂ to characterize sources & links • http://oco.jpl.nasa.gov	2008					
	Terra Global measurements of atmosphere, land & oceans mainly to improve understanding of Earth's energy & carbon budgets • http://terra.nasa.gov	1999					
	TRMM Tropical Rainfall Measuring Mission • Monitor & study tropical rainfall • http://trmm.gsfc.nasa.gov	1997					

NOTE: This table does not represent all of NASA's past and future Earth science missions.

Please visit • <http://www.asd.ssc.nasa.gov/m2m> • to learn about all of NASA's Earth science missions.